APPLICATION FOR
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FOR

FLAVORED EXTRUDED FOOD PRODUCT

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BACKGROUND OF THE INVENTION

1. Cross-Reference to Related Application:

This application is a continuation-in-part of U.S. patent application Ser. No. 10/047,503, filed on October 29, 2001, the technical disclosure of which is hereby incorporated herein by reference.

2. Technical Field:

The present invention generally relates to the production of flavored, direct expanded (*i.e.*, puff extruded) farinaceous food products utilizing an apparatus and method for adding a fluid additive into an extrudable food mass. More specifically, the invention is concerned with an improved extruder die assembly and method for using same to impart a distinct colored and/or flavored pattern into an extrudable food mass during extrusion, and with a method and composition for producing a dried, flavored, direct-expanded food product requiring no post-extrusion drying or seasoning process by utilizing the improved extruder die assembly.

3. Description of the Related Art:

The use of extrusion devices is prevalent in a number of industries, especially the food industry. Utilized to produce a variety of products such as ready-to-eat (R-T-E) cereals, snack foods and confections, extrusion remains prominent among food processes because of its versatility and efficiency.

Food processes utilizing extrusion devices typically include an edible substance such as dough which is introduced into a device and conveyed via a screw pump to an inlet where the substance is forced through an extruder die. The extruder die may perform a variety of functions: it may form or shape the extrudate; it may divide the extrudate into a multiple extrudates; it may inject an additive substance into the extrudate; and it may compress and reduce the cross-sectional area of the extrudate.

Examples of devices used for extrusion of food products are illustrated in U.S.

Patents Nos. 2,858,217; 3,314,381; and 5,639,485. While extrusion dies have evolved over the years, the method by which an additive substance is supplied and injected into the extrudate has remained essentially unchanged.

For Example, in U.S. Patent No. 2,858,217 to Benson, the introduction of coloring matter, such as a colored liquid dye, is accomplished via a series of apertures 40, 42, 44 disposed in the bridging strips 32, 34, 36 and supplied by horizontal passages 52, 54, 55 which are in fluid communication with the dye reservoir 46. The supplying of the liquid dye from the dye reservoir 46 to series of apertures 40, 42, 46 is by means of gravitational force. According to the Benson '217 device, dough material 18 is extruded through a divider block 22 which forces the dough material 18 to divide or spread around the bridging strips 32, 34, 36 so that voids 38 are formed into which the coloring matter is introduced via the series of apertures 40, 42, 44.

Similarly, in U.S. Patent No. 3,314,381 to Fries *et al.*, the fluid injection assembly is comprised of a hollow tubular injection member 29 in a helical spiral configuration, which includes a bore 37 through which pressurized injection fluid is supplied from a source 25 to a plurality of longitudinally spaced bores 39 into a distributing channel 38. The fluid along the length of channel 38 is injected into the passing dough as a substantially longitudinally continuous spiral band extending from substantially the central axis of the dough to either the outer face of the dough or a point short thereof. However, the Fries *et al.* '381 device is primarily adapted to relatively low pressure comestible extrusions.

Finally, U.S. Patent 5,639,485 to Weinstein *et al.* and its related patents, disclose a method and apparatus for adding additives in flowing dough to make complexly patterned multicolored extrudates. The Weinstein *et al.* '485 invention and its progeny all disclose a high pressure extrusion device comprising an extruder die insert 20 which includes means for imparting at least one interstitial gap in the flowing dough by means of a plurality of dividing passageways (*e.g.*, 44, 45, 46) formed by die dividing members 47. An additive (*e.g.*, a food color or a second colored dough) may be injected via a

plurality or array of evenly spaced food color injection ports 48 formed on the downstream side of die dividing member 47. The injection ports 48 are in fluid communication with a pressurized color supply 18 by means of a supply ports 52, 54, 56 and supply passageway 50. The color fluid tends to fill the interstitial gaps in the flowing dough between passageways (*e.g.*, 44, 45, 46) formed by and behind the die dividing members 47 to create a line in the shape of dividing members 47 in the extruded dough. The die insert 20 also includes notches 57 which are used to isolate the color fluid injected into the interstitial gap from spreading to the interior surface wall of die insert 20 thereby reducing if not eliminating the leakage on color fluid onto the outside of the extruded dough. Additionally, the die insert 20 can further include a means for sealing (*e.g.*, "O" rings 60 and 62 as depicted) the color fluid supply reservoir 58 against premature admixture with dough.

In addition to the die insert element, the Weinstein *et al.* '485 invention also comprises a reducing passageway 25 whereby the extrudate's cross-sectional area is significantly reduced. At high operating pressures, the convergence of the passageway 25 inherently creates a significant back pressure on the downstream side of the extruder die insert 20 which, in turn, can contribute to and promote the clogging of the individual injection ports 48. Moreover, the utilization of notches 57, sealing means 60, 62 and multiple enclosed injection ports 48 further complicates the design of the die insert making it harder to clean and maintain. Finally, injecting color fluid at discrete locations into downstream voids or interstitial gaps to disperse the fluid in a generally uniform manner requires precise control of flow rates, internal pressures, and viscosity of the extrudate and various additives. Furthermore, the design of each die insert 20 is limited to the physical constraints imposed by the previously mentioned design elements.

What is needed is an extruder die assembly capable of operating at a variety of operating pressures which has improved seal characteristics and is simpler and easier to maintain and whose injection mechanism is less prone to clogging and blockages.

In addition, extrusion devices are increasingly utilized to impart heat to the base substance during its transit through the extruder device. Typically, a casing surrounding the extrusion chamber is adapted to impart heat to the substance in accordance with practices commonly known in the art. For example, cooker extruders are used to prepare cooked dough extrudates that may then be formed into individual cereal or snack pieces, and subsequently baked or fried. One variation of cooker extruders that is increasingly popular comprises an extruder wherein the conditions of the extruder and the cooked cereal dough are such that the dough puffs immediately upon being extruded and is cut into individual puffed pieces at the die head. Such a process is referred to generally as "direct expansion" or "puff extrusion."

The flavoring of extruded food products typically comprises either flavoring the base substance prior to its introduction to the extruder device, adding a flavoring to the base substance within the extruder device wherein it is admixed utilizing a screw pump mechanism, or flavoring the resulting extruded food piece subsequent to the extrusion process. However, inducing heat to the base substance during an extrusion process adversely affects the flavoring of the resulting extruded food product. Many flavoring are particularly sensitive to heat induced during the manufacturing process. For example, spicy flavorings (*e.g.*, green pepper, chiplotle, and jalapeño) and salty dairy flavors (*e.g.*, cheddar cheese and sour cream) are particularly susceptible to flavor diminishment or deterioration when exposed to heat for an extended period of time during a direct expansion extrusion process. Even sweet flavorings (*e.g.*, strawberry, chocolate, vanilla, *etc.*), while more heat tolerant than other flavoring, are, nevertheless, somewhat degraded when exposed to heat during the manufacturing process. Thus, the flavoring of direct expansion food products usually occurs during a separate seasoning step, which occurs subsequent to the direct expansion extrusion process. Flavorings are typically sprinkled on and admixed with a mass of direct expansion food product on a conveyor belt mechanism or in a tumbling drum mechanism. The tumbling mechanism ensures even coverage of the extruded product.

While the adverse effects caused by heat on flavorings can be avoided by utilizing an extruder mechanism which does not induce heat to the base substance during an extrusion process, the resulting flavored extruded pieces will typically still require a subsequent drying process. Moreover, the dried, flavored, extruded pieces will also have to be subsequently baked or fried, which will similarly affect adversely the quality of the flavoring.

Thus, a need exists for a more efficient system for flavoring extruded food products during a production run of a cooker extrusion device. In this regard, it would be particularly desirable if the seasoning or flavoring of direct expanded food products could be accomplished in a one-step extrusion process (*i.e.*, without a separate seasoning step subsequent to the extrusion process and without a substantial degradation of heat sensitive flavorings injected prior to the extrusion process).

SUMMARY OF THE INVENTION

The present invention overcomes many of the shortcomings inherent in previous methods and systems addressing extruder die assemblies. The present invention comprises an improved extruder die assembly and method for using same to impart a distinct colored and/or flavored pattern into an extrudable food mass during the extrusion process.

In one embodiment, the system comprises an extruder die assembly and method for using same which includes a forming section and an injection section fabricated as a matching set. When properly aligned and coupled, the matching set forms a peripheral reservoir manifold, internal to the die assembly, through which a fluid additive may be supplied via a supply port to at least one and more preferably a plurality of capillary channels which in turn impart a distinct cross-sectional design into a flowing mass of a first extrudate.

In another embodiment, the system and method for using the present invention includes partitioning the internal peripheral reservoir manifold so that a plurality of supply ports may be used to allow different colors and/or flavors to be injected at different locations in the distinct cross-sectional design.

In another embodiment, the system and method for using same utilizes multiple matched sets of forming sections and injection sections in tandem to impart multiple pattern designs into an extrudable food mass.

In another embodiment, the system and method for using same utilizes multiple matched sets of forming sections and injection sections in tandem to impart multiple pattern designs of differing colors and/or flavors into an extrudable food mass.

In another embodiment, the system and method for using same utilizes a converging nozzle to decrease the extrudate's cross-sectional area while maintaining the distinct cross-sectional design pattern imparted into the extrudate.

Thus, in accordance with one feature of the invention, the present invention is

comprised of an extruder die assembly capable of operating at a variety of operating pressures which has improved seal characteristics and is simpler and easier to maintain. Moreover, the performance of the extruder die assembly of the present invention is more stable in that surging of the fluid additive is inhibited thereby resulting in a continuous well defined pattern being injected into the extrudable food mass.

In accordance with another feature of the invention, the present invention is comprised of an extruder die assembly whose injection mechanism is less prone to clogging and blockages. The system of the present invention allows the flow of the extrudable food mass to be momentarily halted without permanently plugging the supply passageways or injection section(s).

A novel feature of the invention is an injection nozzle which supplies fluid additives from an exterior pressurized source to a supply port formed in the extruder die assembly. The subject injection nozzle exhibits superior sealing qualities in conjunction with simplicity and flexibility. The minimal affected space required to receive the subject injection nozzle allows a single extruder die assembly to have more than one supply port fashioned therein. Thus, multiple injection nozzles may be used to supply a single extruder die assembly with multiple colors and/or flavors. The injection nozzle of the present invention also exhibits a unique dual seal characteristic, which is particularly effective in conditions involving high temperature. The subject injection nozzle is also highly flexible in that one injection nozzle may be used interchangeably with another (*i.e.*, each injection nozzle is not unique to a particular supply port).

A novel food product may also be produced in accordance with another feature of the invention, wherein a known composition of a farinaceous food product is extruded through the extruder die assembly of the present invention to produce a flavored direct-expanded food product exhibiting enhanced flavor characteristics while requiring no post-extrusion drying or seasoning process. The injection section of the extruder die assembly is used to impart flavoring additives into the extrudate mass shortly before expansion, thereby preserving the flavoring characteristics of the additive by minimizing the heat

exposure of the flavoring additive. The extruder die assembly may also include static mixing elements downstream from the injection section to homogenize the flavoring or seasoning media into the flowing mass of extrudate. In particular, the present invention may be used to combine heat sensitive flavorings into a farinaceous food mixture to produce a flavored, direct expanded, farinaceous food product without the use of a drying apparatus or a seasoning step subsequent to the extrusion process.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1a is a cut-away perspective view of the extruder die assembly of the present invention;

Figure 1b is a cut-away exploded perspective view of the extruder die assembly of the present invention;

Figure 2a is an overhead view of the forming section of the extruder die assembly of the present invention;

Figure 2b is a cut-away perspective view of the forming section of the extruder die assembly of the present invention;

Figure 3a is an overhead view of the injection section of the extruder die assembly of the present invention;

Figure 3b is a cut-away perspective view of the injection section of the extruder die assembly of the present invention;

Figure 4 is a perspective in partially exploded view of the exit face of a die plate assembly attached to a food cooker extruder showing the extruder die assembly of the present invention and associated injection nozzle assemblies;

Figure 5a is a partial sectional view of the die plate assembly taken along lines 5 – 5 in Figure 4, showing the extruder die assembly and injection nozzle of the present invention properly aligned and inserted therein;

Figures 5b and **5c** are enlarged sectional views of the interface between the extruder die assembly and associated injection nozzle shown in Figure 5a; and

Figure 6 is perspective in partially exploded view of an alternate embodiment of the extruder die assembly of the present invention illustrating an integral static mixer element.

Where used in the various figures of the drawing, the same numerals designate the same or similar parts. Furthermore, when the terms "top," "bottom," "first," "second," "upper," "lower," "height," "width," "length," "end," "side," "horizontal," "vertical," and similar terms are used herein, it should be understood that these terms have reference only to the structure shown in the drawing and are utilized only to facilitate describing the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

An extruder die assembly, generally indicated by reference character **100** in **Figures 1a** and **1b**, includes a forming section **200**, an injection section **300**, and a nozzle section **400**. The three sections comprising the die assembly **100** are coaxially aligned and interlocking. Additionally, means for coupling the forming section **200** to the injection section **300** are also included.

The extruder die assembly **100** is designed for adaptation to a wide variety of commercial-grade extrusion devices common in the food industry. The extruder die assembly **100** is inserted into an appropriate compartment within an extrusion device (not shown) such that a first extrudate (*e.g.*, a paste or a cereal dough) is directed down a coaxially aligned passageway **210** within the forming section **200** and combined with a fluid additive (*e.g.*, a food coloring dye or a flowable colored and/or flavored food material) in the injection section **300** via supply port **340** and annular reservoir **R**, whereupon the resulting food mass is compressed through a converging nozzle bore **420** in the nozzle section **400** to produce an extruded food product containing a distinct colored and/or flavored pattern.

While the embodiment illustrated is shown as being generally cylindrical in shape, the exterior housing of the die assembly **100** may be of any shape necessary for adaptation to commercial-grade extrusion devices common in the food industry. Similarly, while passageway **210** and bore **420** are depicted as having a circular cross sectional area, in other embodiments, passageway **210** and bore **420** can be fabricated with a more complex peripheral configuration to define or define in part the exterior shape or configuration of the finished piece, including both regular shapes (*e.g.*, stars, rings, geometric shapes) as well as irregular shapes (*e.g.*, animals, vegetables, objects such as trees, cars, *etc.*).

Referring to the figures, and in particular **Figures 2a** and **2b**, the forming section **200** is a generally tubular flange element having a central bore defining a passageway **210**. The inlet **212** of the passageway **210** is adapted to receive a conduit (not shown) supplying a pressurized first extrudate from an extrusion device (not shown). A plurality of

counter-sunk coupling holes **202**, equally spaced around the periphery of the entrance face **204** of forming section **200**, are provided for receiving screws (not shown) for removably coupling the forming section **200** to threaded holes **302** in the injection section **300**. An alignment hole **206** extends through the forming section **200** in parallel alignment with the passageway **210** to receive an alignment knob **306** on the entrance face **304** of the injection section **300**. When properly seated into the alignment hole **206**, the alignment knob **306** ensures that the axial angular alignment of the injection section **300** in relation to the forming section **200** is correct.

The outlet portion of the passageway **210** includes a forming die element **220** which divides the flow of the first extrudate into at least two, and more preferably a plurality of adjacent flowing extrudate passageways such as passageways **a-g** respectively formed by forming die element **220**.

The forming section and injection section are fabricated as a matching set. In general, the outlet portion of the forming section is designed to mate and seal with the inlet portion of the injection section. In one embodiment, an inner peripheral rim formed in the outlet portion of the forming section is specifically designed to slidably couple and align with a central bore in the inlet portion of the injection section. The inner peripheral rim is defined by a peripheral notch formed in the outlet face of the forming section. The peripheral notch is characterized by a peripheral rim wall which is parallel with and generally equidistant from the outer periphery of the central passageway. The inner peripheral rim includes a peripheral groove with a semicircular cross-section. A matching peripheral groove with a semicircular cross-section is formed in the base of the central bore of the inlet portion of the injection section such that when the forming section and injection section are slidably coupled and aligned, an internal peripheral reservoir manifold with a circular cross-section is formed.

Thus, as shown in the figures, and in particular **Figures 2b**, **3a**, and **3b**, when the present invention is realized in an embodiment having a generally circular cross section, the inner peripheral rim formed in the outlet portion of the forming section **200** is an

annular rim defined by an annular notch, characterized by the annular rim wall **242** and the annular outer ring seal face **240**, around the outer periphery of the outlet face of the forming section **200**. The annular rim in the outlet portion of the forming section **200** slidably fits into a central bore in the inlet portion of the injection section **300** defined by the annular bore wall **308** such that the forming section's annular outer ring seal face **240** seats and seals with the injection section's annular outer seal face **304**, the forming section's intermediate annular seal face **244** seats and seals with the injection section's annular intermediate ring seal face **310**, and the forming section's inner annular seal face **246** and the exit face **248** of the forming die element **220** seat and seal with the entrance face **322** of the injection section's co-injection die insert **320**. Moreover, the matching annular peripheral grooves **230** and **330** form an annular internal peripheral reservoir manifold **R** into which a fluid additive may be supplied. When properly aligned and coupled, the respective-annular seals between the forming section **200** and the matching injection section **300** effectively seal and isolate the fluid additive supplied to the reservoir manifold **R** from inadvertent leakage to the upstream side of the forming die element **220** and the outer periphery of the extruder die assembly **100**.

The injection section **300** includes a co-injection die insert **320** which has profile such that when properly aligned with the forming die element **220**, passageways **a'-g'** are respectively adjoined with passageways **a-g** formed by forming die element **220**. When properly aligned and coupled, the seal between the exit face **248** of the forming die element **220** and the entrance face **322** of the injection section's co-injection die insert **320** ensures that the respective adjacently flowing extrudate passageways are unobstructed and contiguous and that the fluid additive contained in the reservoir manifold **R** does not inadvertently leak to the upstream side of the forming die element **220**.

The co-injection die insert **320** includes at least one and more preferably a plurality of capillary channels **352** in the space between the plurality of passageways. The capillary channels **352** are fluidly connected to the reservoir manifold **R** via channel ports **350**. The reservoir manifold **R** is fluidly connected to a pressurized source of fluid

additive (not shown) via supply port **340**.

When properly aligned and coupled, the seal between the exit face **248** of the forming die element **220** and the entrance face **322** of the injection section's co-injection die insert **320** ensures that the pressurized fluid additive supplied to the annular internal peripheral reservoir manifold **R** continually charges the capillary channels **352** via channel ports **350** whereupon each capillary channel **352** emits at its downstream exit face a continuous discharge of fluid additive in the general cross-sectional shape of the capillary channel **352** resulting in a continuous band of fluid additive being injected into the transient clefts formed in the first extrudate as it exits the adjacent flowing extrudate passageways such as passageways **a'-g'**. Upon exiting from the individual adjacent flowing extrudate passageways (*e.g.*, passageways **a'-g'**), the individual adjacently flowing columns of first extrudate coalesce to enclose the injected bands of fluid additive within a single flow mass thereby imparting a distinct colored and/or flavored pattern into the food mass.

In an alternative embodiment of the present invention, the injection section **300** may include multiple supply ports **340** fluidly connected to separate pressurized sources of fluid additive. In such an embodiment, the annular internal peripheral reservoir manifold **R** may be divided into multiple segregated quadrants fluidly connecting individual pressurized sources of fluid additive to specific capillary channels **352** allowing a distinct pattern of multiple colors and/or flavors to be imparted into the food mass.

In one embodiment of the present invention, the exit face **362** of the injection section **300** is generally designed to mate and seal with the inlet face **404** of the nozzle section **400**. With the exception of the co-injection die insert **320**, the inlet face **404** of the nozzle section **400** is essentially a mirror image of the exit face **362** of the injection section **300**. In general, the nozzle section **400** includes an inlet with a periphery matching the periphery of the forming section's passageway. The nozzle section further includes a passageway coaxially aligned with the forming section's passageway which converges to an outlet. As the passageway converges, the passageway's cross-sectional

decreases while its aspect ratio is generally maintained. Thus as shown in the figures, and in particular **Figures 1b** and **3b**, when the present invention is realized in an embodiment having a generally circular cross section, the nozzle section **400** includes an inlet **410** with an inner annular periphery which matches the periphery of the forming section's passageway **210**. The nozzle section further includes a passageway **420** coaxially aligned with the forming section's passageway **210** which converges to an outlet **430**.

In an actual embodiment having a circular cross section as illustrated in **Figure 1b**, the diameter of passageway **420** is reduced from 0.664 inches at inlet **410** to 0.332 inches at outlet **430**. In another such embodiment, the diameter of passageway **420** is further reduced from 0.664 inches at inlet **410** to 0.153 inches at outlet **430**.

Alternatively, in another embodiment of the present invention, multiple sets of matching forming/injection sections may be adjoined in a tandem or series arrangement. In such an embodiment, the inlet face of a second set's forming section is designed to mate and seal with the exit face of a first set's injection section. Arranging multiple sets of matching forming/injection sections in tandem allows multiple pattern designs of differing colors and/or flavors to be imparted into an extrudable food mass.

As previously noted, the extruder die assembly **100** of the present invention is designed for adaptation to a wide variety of commercial-grade extrusion devices common in the food industry. The extruder die assembly **100** is typically inserted into a sealable compartment attached to or within an extrusion device (not shown), such that the inlet **212** of the forming section **200** of the extruder die assembly **100** is connected via a conduit to an output port of the extrusion device. For example, as illustrated in **Figure 4**, such a compartment may comprise a die plate assembly **500** attached to the outlet section of a conventional cooker extruder device. The die plate assembly **500** includes a main die plate **510** having a main bore **512** defined therethrough for receiving an extruder die assembly **100**. The circumferential dimensions of the main bore **512** is complementary to that of the extruder die assembly **100**, so as to ensure a snug fit and minimal extrudate leakage therebetween. When an extruder die assembly **100** is inserted into the main bore

512 of the main die plate **510**, the outlet **430** of the nozzle section **400** protrudes slightly past the exit face **514** of the main die plate **510**.

The main die plate **510** also includes an injection port **520** formed in the sidewall **516** of the main die plate **510** for receiving an injection nozzle **600**. The injection port **520** extends through the sidewall **516** to the main bore **512** at an angle generally perpendicular to the longitudinal axis of main bore **512**. The injection port **520** is further positioned such that when an extruder die assembly **100** is inserted into and properly aligned with the main die plate **510**, the injection port **520** aligns with a corresponding supply port inlet **342** formed in the injection section **300** of the extruder die assembly **100**. The main die plate **510** may further include additional injection ports (*e.g.*, **522**) for receiving additional injection nozzles (*e.g.*, **602**), for use with an extruder die assembly **100** having multiple supply port inlets **342** formed in the injection section **300** thereof. When not required, the additional injection ports (*e.g.*, **522**) may be sealed with a suitable plug device (not shown).

In addition, the die plate assembly **500** also typically includes a conventional feed plate (not shown) which seals the entrance face of the main die plate **510** and has a passageway defined therethrough which acts as a conduit between the output port of the extrusion device and the inlet **212** of the forming section **200** of the extruder die assembly **100**. The feed plate may also provide attachment points for connecting the die plate assembly **500** to the outlet section of the extrusion device.

Referring now to the Figures, and in particular to **Figures 5a**, **5b** and **5c**, which depict various cross-sectional views of the die plate assembly illustrated in **Figure 4**, a novel feature of the invention is shown, which comprises an injection nozzle **600** that supplies fluid additives from an exterior pressurized source to a supply port **340** formed in the injection section **300** of the extruder die assembly **100**. The injection nozzle **600** of the present invention exhibits enhanced sealing characteristics while supplying pressurized fluid additives to an extruder die assembly **100** inserted in a die plate assembly attached to a conventional cooker-extruder device.

The injection nozzle **600** generally comprises an inlet section **610**, a mid-section **620**, and a outlet section **630**. The inlet section **610** is designed to receive and couple with a pressurized additive supply line **670** so as to establish fluid communication with the exterior pressurized source. In the embodiment shown in the Figures, the inlet section **610** comprises a standard hexagonal NPT threaded female fitting which is designed to engage a conventional threaded male fitting **650** attached to the pressurized additive supply line **670**.

The mid-section **620** comprises an externally threaded barrel having a smooth-bore interior passageway **616** in fluid communication with an inlet space **612** defined in the inlet section **610**. The threaded mid-section **620** allows the injection nozzle **600** to be securely mounted into the threaded injection port **520** formed in the main die plate **510**, thus forming a leak-proof assembly.

The outlet section **630** comprises a smooth, tapered end having a discharge port **618** at its distal end which is in fluid communication with the interior passageway **616**. The diameter of the discharge port **618** is typically less than the diameter of the supply port **340**. The outlet section **630** is generally paraboloididal shaped having a spherical tip of a given radius r_1. The spherical tip of the outlet section **630** is complementary with the spherical concavity of a given radius r_2 which defines the supply port inlet **342** formed in the injection section **300** of the extruder die assembly **100**. The complementary shapes of the spherical tip of the outlet section **630** and the supply port inlet **342** provide a relatively larger contact area per unit volume of perforation inside the injection section **300** of the extruder die assembly **100**, thereby resulting in an enhanced sealing mechanism. The resulting increase in the metal-to-metal contact between the outlet section **630** of the injection nozzle **600** and the supply port inlet **342** thereby facilitates a non-invasive fluid connection with robust sealing characteristics.

Thus, in addition to the threaded portion **614** of the inlet section **610**, which effectively seals the connection between the injection nozzle **600** and the pressurized additive supply line **670**, the injection nozzle **600** of the present invention exhibits a

unique dual seal characteristic. First, the threaded mid-section **620** effectively seals the injection port **520** preventing extrudate from leaking out from the interior main bore **512**. Second, the complementary shapes of the spherical tip of the outlet section **630** and the supply port inlet **342** effectively seals the pressurized fluid additives from leaking out to the outer periphery of the extruder die assembly **100**.

The dual seal characteristic is particularly effective in conditions involving high temperature. In such conditions, components of the die plate assembly **500** typically expand, oftentimes resulting in a corresponding increase in the gap between the extruder die assembly **100** and the interior main bore **512**. The dual seal characteristic of the injection nozzle **600** allows both sealing mechanisms to be adjusted, independent of one another, in response to changes induced by high temperature conditions.

Furthermore, the injection nozzle **600** of the present invention promotes a simpler and more flexible injection system. For example, while in theory a sealing thread mechanism could be extended along the entire length of the nozzle, this would require a much larger volume of perforation inside the injection section of an extruder die assembly to achieve an equivalent contact and sealing area. Moreover, to insure a continuous threaded seal, the bore of the injection port and the supply port inlet would have to be threaded concurrently, thereby dictating a matched set arrangement comprised of an injection nozzle, an injection section, and a die plate.

On the other hand, the reduced injection section perforation requirement of the injection nozzle **600** of the present invention allows greater flexibility in the number of nozzles used and the positioning of the nozzles in a particular application. Moreover, the injection nozzle **600** of the present invention allows greater simplicity while improving the flexibility of the entire system in that generic components may be fashioned so as to be essentially interchangeable with like generic components. For example, the injection nozzle **600** may standardized so as to be interchangeable with any other generic injection nozzle. The dimensions and position of the supply port inlet **342** formed in assorted injection sections may also be standardized allowing a generic injection nozzle having a

standardized tip to be used with all of them. In addition, the dimensions of the threaded injection ports on the main die plate may be standardized so as to accommodate all injection nozzles having a generic threaded barrel mid-section. Likewise, the position of the threaded injection ports on the main die plate may be standardized so as to align with the supply port inlet **342** on all extruder die assemblies having a generic injection sections. Thus, by standardizing the injection nozzle **600**, the injection port **520**, and supply port inlet **342**, extruder die assemblies having different forming die elements **220** and co-injection die inserts **320** are easily interchangeable with one another.

While the embodiment of the injection nozzle **600** illustrated in the Figures is shown as a unitary component, it is understood that other variants of the injection nozzle **600** of the present invention may be comprised of separate sections which are selectively coupled to one another.

In yet another embodiment of the present invention, a known extrudate composition of a farinaceous food product is extruded through the extruder die assembly **100** to produce a flavored direct-expanded food product that exhibits enhanced flavor characteristics requiring no post-extrusion drying or seasoning process. The production of a flavored extruded food product requiring only minimal post-extrusion processing for drying and seasoning is very appealing because of the obvious simplification in the manufacturing process. An essential feature of this embodiment of the invention is the ability to add a flavoring additive in a one-step, direct-expanded extrusion process without substantially degrading the flavoring characteristics of the additive.

U.S. Patent No. 4,869,111 to Keller, the technical disclosure of which is hereby incorporated herein by reference, discloses a composition of farinaceous food product that is well suited for use as the flowing mass of a first extrudate in the present invention. Such an extrudate composition comprises a fluid farinaceous food mixture containing from about 5 weight percent to about 17 weight percent of at least one plasticizer selected from monosaccharides, polysaccharides, and edible alcohols, including ethanol and

glycerol, and having a moisture content from about 9 weight percent to about 17 weight percent.

The food material which may be used in the process of the invention can be any farinaceous material. The material will generally be in granular or powdered form such as meal, flour, or starch derived from corn, wheat, rice, oats, barley, potatoes, rye, tapioca, and other cereal crops, legumes or tubers. The preferred farinaceous material is corn meal. The granular or powdered farinaceous food mixture used in the process contains between about 9 weight percent and about 17 weight percent moisture, based on total weight of the mixture. The farinaceous material, as it is provided from a flour milling operation, usually contains sufficient moisture to provide this level. However, if necessary, a small amount of water can be added to achieve the desired level.

The plasticizer is selected from the group consisting of monosaccharides, polysaccharides, edible alcohols and mixtures thereof. Mixtures of polysaccharides employed preferably have a substantial portion of this mixture consisting of mono-, di-, and tri-saccharides. Useful monosaccharides include, for example, glucose (dextrose) and fructose. The useful polysaccharides include disaccharides, such as sucrose and maltose, and mixtures of various chain length saccharides, such as corn syrup solids, maltodextrins, and polydextrose. The useful edible alcohols include ethanol and glycerol.

It is preferred to use plasticizers selected from the group consisting of sucrose, corn syrup solids, maltodextrin, polydextrose, and glycerol. Corn syrup solids of varying dextrose equivalents (DE) have been used successfully. One embodiment of the subject invention uses Maltrin® M365 (DE 36) manufactured and sold by Grain Processing Corporation of Muscatine, Iowa which contains about 50% saccharides of chain length of 3 saccharide units or less. However, other polysaccharide mixtures having other dextrose equivalents may be used. For example, FRO-DEX® Z 24 (DE 28) manufactured by American Maize-Products Company of Hammond, Ind. contains about 25% mono-, di-, and tri-saccharides and FRO-DEX® 42 (DE 42) contains about 45% mono-, di-, and tri-saccharides. Both of these have performed similarly when compared with the Maltrin®

M365. The particular choice of plasticizer may depend on a number of practical factors, including cost and the flavor desired in the end product. Since the expanded farinaceous product may be combined with a salty flavoring (*e.g.*, a savory cheese flavoring), it is often desired that the farinaceous product have a minimal amount of sweetness. Large amounts of sucrose, dextrose, or fructose should be avoided in such case. Corn syrup solids or maltodextrins, on the other hand, are only slightly sweet and polydextroses are essentially non-sweet. Glycerol has a slight sweetness, but its flavor is generally not considered agreeable when used at relatively high concentrations.

For producing a low-sweetness, direct-expanded farinaceous product, a mixture containing from about 4.0% to 6.0% corn syrup solids, from about 0.5% to 2.0% sucrose, from about 3.0% to 6.0% polydextrose and from about 0.5% to 2.5% glycerol, is preferred as the employed plasticizer component, based on the total weight of the farinaceous food mixture which is fed to the extrusion device.

Whereas the preceding is directed to the preparation of low sweetness expanded farinaceous products, this invention may also be used for the preparation of moderate to high sweetness expanded farinaceous products. This can be accomplished by using higher levels of the sweeter tasting plasticizers, such as sucrose, fructose, and glucose or other sweeteners known to those skilled in the art. In this case, the sweeter tasting plasticizers can be used alone or in combination with the less sweet plasticizers at levels of from about 6.0 weight percent to about 15.0 weight percent.

If desired, other conventional additives can be present in the farinaceous food mixture. For example, emulsifiers, salt, fats, food dyes and flavorings may be present in the mixture in the amounts necessary to provide a desired effect.

Thus, in accordance with the general parameters of the present invention, the known extrudate composition is extruded in a standard twin- or single-screw extrusion device fitted with the extruder die assembly **100**. A flowing mass of the known extrudate composition is directed to the inlet **212** of the passageway **210** within the forming section **200** and combined with a flavored fluid additive (*i.e.*, a flavoring and/or flavored food

material) in the injection section **300**. The flavored fluid additive may comprise a heat sensitive flavoring (*e.g.*, spicy flavorings such as green pepper, chiplotle, and jalapeño; or salty dairy flavors, such as savory cheese and sour cream) or a heat tolerant flavoring (*e.g.*, sweet flavorings such as strawberry, chocolate, vanilla, *etc.*). While heat tolerant flavorings are less susceptible to the adverse effects of heat induced during the manufacturing process, they can, nevertheless, benefit from the method of the present invention in that overall flavor loss is reduced producing a higher intensity of flavor at reduced concentrations.

While any extruder die assembly of the present invention is capable of imparting flavored fluid additive in a distinct flavor pattern in the flowing mass of the known extrudate composition, the extruder die assembly may be constructed so as to maximize the amount of flavored fluid additive that may be imparted into the flowing extrudate composition with no regard for any corresponding pattern. For example, as shown in **Figure 6**, in a preferred embodiment the extruder die assembly **100A** may comprise co-injection die insert **320A** featuring a cross-hatched design. The cross-hatch design maximizes the amount of flavored fluid additive imparted into the cross-section of the flowing extrudate. The extruder die assembly **100A** may also include static mixing elements (*e.g.*, **600a, 600b, 600c**) located downstream from the co-injection die insert **320A** of the injection section **300A**. The static mixing elements (*e.g.*, **600a, 600b, 600c**) serve to homogenize the flavoring or seasoning media throughout the flowing mass of extrudate. The inlet of the nozzle section **400A** may be adjusted to accommodate the inclusion of static mixing elements (*e.g.*, **600a, 600b, 600c**) within the extruder die assembly **100A**.

After passing through the injection section **300A** and any static mixing elements (*e.g.*, **600a, 600b, 600c**), the resulting flavored food mass is then compressed through a converging nozzle bore in the nozzle section **400A** such that the pressure in nozzle bore is equal to or in excess of the vapor pressure of the water in the flavored extrudate mixture, and flavored extrudate mixture through a profile die (*e.g.*, outlet **430A**) into a zone of

ambient pressure below the vapor pressure of the water in the mixture. As the flavored extrudate mixture emerges from the die into the zone of reduced pressure, a portion of the water in the mixture is vaporized, thereby causing the product to expand. The resulting extruded flavored food product has a moisture content from about 4 weight percent to about 8 weight percent and a water activity (A_w) from about 0.30 to about 0.45.

The extrusion device of the present invention must be capable of generating super-atmospheric pressures and elevated temperatures in the material being extruded. Preferably, the extruder employed is a twin screw extruder. The twin screw extruder houses two adjacent, parallel screws which are operated in a co-rotating mode. Suitable twin screw extruders can be obtained commercially and include, for example, a Baker-Perkins model MPF-50D twin screw extruder.

In the practice of this invention, it is preferred to employ a screw configuration which imparts relatively low shear forces to the farinaceous food material. A preferred screw for use in conjunction with a Baker Perkins MPF-50D twin screw extruder has the following configuration, proceeding from the inlet of the extruder barrel towards the extruder die assembly **100A**:

First, a 10" long metering screw;
Second, a 31/2" long 30° forward paddle section;
Third, a 3" long single lead screw;
Fourth, a 2" long 60° forward paddle section;
Fifth, a 6" long single lead screw;
Sixth, a 2" long 60° forward paddle section;
Seventh and last, a 3" long single lead screw.

The farinaceous food mixture is placed in a feed hopper which feeds the extruder barrel. As the mixture is moved through the extruder barrel by the action of the rotating extruder screws, the farinaceous food mixture becomes plasticized and flowable. The heat required to plasticize the mixture is generated by the shearing action of the screws.

Heating and cooling devices can also be mounted along the extruder to impart or remove heat in order to obtain the desired temperature profile.

As the farinaceous food material moves through the extruder barrel, the barrel pressure increases. The pressure in the extruder barrel equals or exceeds the vapor pressure of the water in the farinaceous food mixture at all times, thus preventing the water from vaporizing prior to emergence from the extruder.

The plasticized farinaceous food mixture exits the extruder barrel and is directed to the inlet of the passageway within the forming section **200A** and combined with a fluid additive (*i.e.*, a flavoring and/or flavored food material) in the injection section **300A** and extruded through outlet **430A** of nozzle section **400A**.

The hot, plasticized, farinaceous food mixture emerges from the outlet **430A** into a zone of ambient pressure below the vapor pressure of the water in the mixture; that is, normal atmospheric pressure. Upon emerging from the extruder die assembly **100A**, the now flavored plasticized, farinaceous food mixture is exposed to the reduced pressure environment, thus readily allowing a portion of the water in the mixture to vaporize so that there is formed a highly porous, puffed, cellular body. In the process of so doing, the residual moisture in the farinaceous product is reduced to a level from about 4 weight percent to about 8 weight percent.

Any suitable die configuration can be employed, depending on the particular product which one desires to make by the process of the invention. For example, as shown in the **Figure 6**, the extruder die assembly **100A** may have a circular cross-sectional are or a "O"-shaped opening to produce a rod of extrudate or ball-shaped extrudate.

As previously indicated, the resulting extruded food product does not require the use of a drying apparatus such as an oven to remove moisture. As it emerges from the outlet **430A** of the extruder die assembly **100A**, the extrudate typically has a temperature from about 121° C. to about 163° C. and is soft, yet self-supporting. The product can be subjected to further processing, *e.g.*, segmenting and bagging, *etc.*, as soon as it has

cooled sufficiently to become rigid and dimensionally stable. If desired, air cooling or other means may be employed to assist in cooling the extrudate. By eliminating the drying and seasoning stage from the production process, the total length of a production line, excluding the extruder, for an expanded, farinaceous food product is typically reduced from about 130 feet to 30 feet or less.

The expanded product is usually cooled to near ambient temperature in about two minutes. The texture is crisp and crunchy, even though a drying oven was not used. Thus, the resulting extruded food product is suitable for providing a shelf-stable snack product.

The following example is intended to further illustrate the known extrudate composition of the invention and is not intended to limit the scope of the invention in any way.

EXAMPLE

A non-sweet, whole wheat flavored product was prepared from the following ingredients:

Ingredients	Parts By Weight
Whole Wheat Flour	58.09
Corn Cones (Corn Meal)	28.00
Corn Syrup Solids (Dextrose Equivalent = 34-38)	5.00
Polydextrose	3.70
Sucrose	1.20
Glycerol	2.50
Salt	0.50
Monoglycerides	0.30
Annatto Powder	0.01
Water	0.70
	100.00

It will now be evident to those skilled in the art that there has been described herein an improved extruder die apparatus and method for imparting a distinct colored and/or flavored pattern into an extrudable food mass during extrusion that may be

subsequently homogenized without regard to any corresponding pattern. In addition, a method for using the improved extruder die assembly with a farinaceous food composition to produce a dried, flavored, direct-expanded food product that exhibits improved flavor characteristics while requiring no post-extrusion drying or seasoning process has been described. Moreover, an injection nozzle having enhanced sealing characteristics and facilitating a non-invasive fluid connection to the improved extruder die apparatus has also been described. Although the invention hereof has been described by way of a preferred embodiment, it will be evident that other adaptations and modifications can be employed without departing from the spirit and scope thereof. For example, multiple extrusion die assemblies may be utilized in a parallel arrangement by a single extruder device. The terms and expressions employed herein have been used as terms of description and not of limitation; and thus, there is no intent of excluding equivalents, but on the contrary it is intended to cover any and all equivalents that may be employed without departing from the spirit and scope of the invention.